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GEOTECHNICAL ENGINEERS INC.


FINAL REPORT  
DESIGN AND COST ESTIMATE FOR  
INSTALLATION OF NEW PIEZOMETERS  
AND REPAIR OF EXISTING PIEZOMETERS AT  
TOWNSHEND DAM, TOWNSHEND, VERMONT AND  
NORTH SPRINGFIELD DAM,  
NORTH SPRINGFIELD, VERMONT  
New England Division  
Corps of Engineers

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Prepared for  
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## 1. INTRODUCTION

### 1.1 Purpose

This report presents the design, specifications, and cost estimates for the installation of seven new piezometers and the repair of four existing piezometers at Townshend and North Springfield Dams in Vermont, as proposed by the New England Division, Corps of Engineers (NED-CE).

### 1.2 Scope

The scope of work performed for this project was as follows:

- a. Review existing data.
- b. Prepare design, specifications, and cost estimate for seven new piezometers.
- c. Prepare design and cost estimate for repairs to four existing piezometers.

This work was performed as part of the design of an automated instrumentation system for the two dams. A copy of the NED-CE Scope of Work is included in Appendix A. The design of the automated system will be included in a future report.

### 1.3 Authorization

The services provided by GEI for Delivery Order No. 1 under Contract DACW33-87-D-0002 were authorized in a letter from NED-CE dated April 24, 1987.

### 1.4 Available Data

The following NED-CE construction plans and data were reviewed for Townshend Dam:

- a. Construction drawings CON-87, Sheet 1 showing the piezometer locations and CT-1-5306 showing embankment sections
- b. Drill logs for the installation of pneumatic piezometers PZ-1, PZ-2, PZ-3, and PZ-4
- c. Drill log for the abandoned borehole FD85-8 for proposed piezometer PZ-5

d. Piezometer data tables

The following NED-CE construction plans and data were reviewed for North Springfield Dam:

e. Construction drawing CON-259, Sheet 1 showing the piezometer locations

f. Piezometer data tables

## 2. SITE AND PROJECT DESCRIPTION

### 2.1 Townshend Dam

Townshend Dam is located on the West River in Townshend, Vermont. It is a unit of the Connecticut River Basin flood control plan. The dam is located about 20 miles upstream of the confluence of the Connecticut and West Rivers at Brattleboro, Vermont.

Townshend Dam is a rolled-earth and rockfill embankment. The embankment is 1,700 feet long and has a maximum height of 133 feet. It has an inclined impervious core with adjacent pervious fill zones and rockfill outer shells. The dam has a crest elevation of 583 feet National Geodetic Vertical Datum (NGVD), a crest width of 25 feet, an upstream slope of 2.5H:1V, and a downstream slope of 2H:1V. A 5-foot-thick impervious blanket extends 500 feet upstream, protected at the west terrace slope by a 2-foot-thick rock blanket on 12 inches of gravel bedding. The west terrace slope is protected by a 3-foot-thick rock blanket which extends 200 feet downstream from the embankment toe. The normal operating reservoir pool for the dam is at 478 feet NGVD.

The project consists of installing five Casagrande-type piezometers. The location of the five piezometers, PZ-1 through PZ-5, are shown in Fig. 1. The required piezometer tip elevations and estimated tip depths below ground surface are included in Table 1.

Piezometers PZ-1 through PZ-4 will be installed from the upstream slope adjacent to four inoperable pneumatic piezometers. The Casagrande-type piezometers will be located within a 5-foot radius of the existing pneumatic piezometers. Piezometers PZ-1 through PZ-3 are located on the upstream 2.5H:1V rockfill slope. Piezometer PZ-4 is located on the impervious upstream blanket. There is about 5 to 6 feet of water at the location of PZ-4 during the normal operating reservoir pool.

Piezometer PZ-5 is located on the crest of the dam. The borehole for PZ-5 (FD85-8) was started in 1985 and stopped at a depth of 95.5 feet because of continuous loss of drilling fluid in the rockfill zone. Four-inch-diameter casing was left in the borehole to a depth of about 71 feet inside of 6-inch-diameter casing that extends to an unknown depth. The boring for installation of piezometer PZ-5 will be continued into the foundation of the dam below the rockfill.



## 2.2 North Springfield Dam

North Springfield Dam is located on the Black River in North Springfield, Vermont. It is a unit of the Connecticut River Basin flood control plan. The dam is located about 10 miles upstream of the confluence of the Connecticut and Black Rivers.

North Springfield Dam is a random-earth and rockfill dam. The embankment is 2,940 feet long with a maximum height of 120 feet above invert elevation. The crest width is 30 feet and is at elevation 1570 feet NGVD, which is 24.5 feet above spillway crest. The embankment slopes vary from 2H:1V to 4H:1V.

The project includes installing two Casagrande-type piezometers along the downstream toe filter just upstream of the seepage pond. The locations of the two piezometers, PZ-13 and PZ-14, are shown in Fig. 2. The required piezometer tip elevations and estimated tip depths below ground surface are included in Table 2.

The project also includes repairing four existing piezometers, PZ-8 and 9 and PZ-10 and 11, in the 1985 remedial repair area of the downstream slope, as shown in Fig. 2. The four piezometers are enclosed in two standpipes consisting of 6-inch-diameter flush joint casing. Currently, the standpipes stick up above the ground 12.5 feet and 19.5 feet and need to be cut down to be able to read the piezometers inside and to install the proposed automated instrumentation system.

### 3. PIEZOMETER DESIGN, INSTALLATION, AND REPAIR

#### 3.1 Piezometer Design

The seven new piezometers at Townshend and North Springfield Dams will all be Casagrande-type piezometers. A diagram of the installation is shown in Fig. 3. Material specifications and installation procedures are provided in the Specifications in Appendix B. The required piezometer tip elevations are provided in Tables 1 and 2 for Townshend and North Springfield Dams, respectively. A summary of the piezometer design is provided below.

A 2-foot-long by 1.5-inch-OD Casagrande-type piezometer tip with a 3/4-inch-ID riser will be installed in a cased borehole advanced 1 foot below the required piezometer tip elevation and flushed clean with water. The piezometer tip will be surrounded with medium sand for a length of 1 foot below and 1 foot above the piezometer tip. A minimum 2-foot-thick bentonite seal will be placed on top of the medium sand, and the remainder of the borehole will be filled with a cement-bentonite grout to the ground surface. Four-inch-diameter casing will be left in the borehole to a depth of 1 foot below the bottom of the rockfill zone and extend about 2 feet above the ground to protect the piezometer riser pipe from the rockfill. The ground surface of piezometer PZ-4 at Townshend Dam is below the normal operating reservoir level, and therefore, sufficient casing will be left in the borehole to extend 2 feet above the normal reservoir level to enable later construction of the automated system.

The contractor will establish an accurate reference elevation at each piezometer location prior to completing the borehole and installing the piezometer so that he can place the piezometer tip at the required elevation.

#### 3.2 Townshend Dam Piezometer Installation

Piezometers PZ-1 through PZ-3 are located on a 2.5H:1V rockfill slope and will probably require construction of a working platform. The ground surface at piezometer PZ-4 is about 5 to 6 feet below the normal operating reservoir level. A barge will be required to install the piezometer. Piezometer PZ-5 is located on the crest of the dam and is accessible by a truck-mounted drill rig.

All of the boreholes for installing the piezometers, except piezometer PZ-4, will require drilling through a zone of rockfill. The estimated depth of the rockfill at each piezometer location is included in Table 1.

The borehole for piezometer PZ-5 was started in 1985 and stopped at a depth of 95.5 feet because of continuous loss of drilling fluid in the rockfill zone. Four-inch-diameter casing was advanced to a depth of about 71 feet and left in the borehole inside of 6-inch-diameter casing which extends to an unknown depth. The boring is planned to be continued into the foundation of the dam to install piezometer PZ-5.

According to the embankment sections in the construction plans, drawing number CT-1-5306, the lower rockfill zone begins at about 65-foot depth, approximately 5 feet above where the previous boring was unable to advance the 4-inch-diameter casing. Also the construction drawing shows that the rockfill zone could potentially be 60 feet thick and may also be only a few feet beyond where the previous boring was terminated.

There are three alternatives for installing piezometer PZ-5 under the crest of the dam in the foundation. There are as follows:

- a. Telescope 3-inch-diameter casing inside of the existing 4-inch-diameter casing and continue advancing the boring.
- b. Move the location of the piezometer towards the west abutment and make a new borehole for the piezometer where the depth to the foundation and thickness of rockfill will be less.
- c. Use a down-hole hammer technique to advance casing to the required depth for installing the piezometer. This would require starting a new borehole adjacent to the abandoned borehole.

Due to the thickness and nature of the rockfill, conventional wash drilling techniques may not be practical for drilling through the rockfill for the piezometer installation. Based on our experience and discussions with drilling contractors, we feel that the down-hole hammer method of drilling is a more feasible alternative for advancing a borehole through the rockfill. The Odex TM system is a down-hole hammer method that has the ability to advance casing with the bit.

We understand that it is current Corps of Engineers' policy not to use the Odex system in embankment dams. As a result, we have prepared specifications for attempting to complete the boring for piezometer PZ-5 by installing 3-inch-diameter casing inside of the existing 4-inch-diameter casing and advancing it into the dam foundation. Significant drilling difficulty is expected, and it may not be possible to complete the boring using this technique.

For the reason given above, we have assumed the borings for PZ-1 through PZ-3 will be drilled using conventional wash drilling techniques. However, to reduce drilling difficulties, we feel that the Odex TM system should be used to drill through the rockfill for these three borings. After a borehole was drilled through the rockfill using the Odex TM system, the casing would be left in the borehole, and the borehole would be completed using conventional wash boring techniques with a smaller diameter casing.

### 3.3 North Springfield Piezometer Installation

The piezometers will be installed along the downstream toe filter, just upstream of the seepage pond. The piezometers locations are on level ground and accessible by a truck-mounted drill rig. We anticipate that the top part of the boring will be through approximately 5 to 10 feet of rockfill.

### 3.4 North Springfield Piezometer Repair

The repairs for the piezometer standpipes will involve cutting the casing off about 6 inches above the lowest exposed joint. This will be accomplished by 1) cutting two holes about 1 foot high on each side of the casing while it is supported at the top by a crane, allowing the sand in the casing to fall out inside of the casing, 2) cutting the PVC riser pipes and covering the tops to prevent sand from entering the piezometers, and 3) then cutting the remaining perimeter of the casing and removing the casing with the crane. Details of the repair procedure are included in the Specifications in the section entitled "Repair of Existing Piezometers."

#### 4. COST ESTIMATES

##### 4.1 Estimated Drilling Contractor Costs

###### 4.1.1 Townshend Dam

The estimated costs for the piezometer installations are summarized in Table 3. Detailed cost breakdowns are presented in Table C1 in Appendix C. The cost items include drilling and SPT sampling at 5-foot intervals below the rockfill, constructing and moving a working platform to each piezometer location on the upstream face of the dam, mobilizing a barge for piezometer PZ-4, mobilizing a separate drill rig for installing piezometer PZ-5 from the crest of the dam, providing and installing the Casagrande-type piezometers and riser pipe, leaving casing in the borehole, and providing a reference elevation at each piezometer location. The unit prices were provided by NED-CE for their contract with Atlantic Test Boring. The estimated total cost for installing all of the piezometers, not including A/E observation services, is about \$32,500.

###### 4.1.2 North Springfield Dam

The estimated costs for the piezometer installations and repairs are summarized in Table 3. Detailed cost breakdowns are presented in Table C2 in Appendix C. The cost items for installing piezometers include drilling and SPT sampling at 5-foot intervals below the rockfill, providing and installing the Casagrande-type piezometers and riser pipe, leaving casing in the borehole, and providing a reference elevation at each piezometer location prior to installation. The cost items for repairing piezometers include a crane and operator. The unit prices were provided by NED-CE for their contract with Atlantic Test Boring. The estimated total cost for installing all of the piezometers and repairing the existing piezometers, not including A/E observation services, is about \$8,400.

##### 4.2 A/E Observation Costs

The estimated cost for A/E observation of the installation and repairs of the piezometers at both dams is about \$28,000. Detailed cost breakdowns are presented in Appendix D. This estimated cost is based on the field work being completed within a 7-week period.

TABLE 1 - PIEZOMETER INSTALLATION  
TOWNSHEND DAM, TOWNSHEND, VERMONT  
Delivery Order No. 1  
Contract DACW33-87-0002

Piezometer No.	Approx. Station	Approx. Offset (ft)	Approx. Ground Elevation (ft)	Piezometer Tip Elevation (ft)	Approx. Tip Depth (ft)	Approx. Depth of Rockfill (ft)	Piezometer Tip Type
PZ-1	21+95	100 U/S	546.9	451.25	95.65	5	Casagrande
PZ-2	21+95	180 U/S	514.9	455.68	59.22	20	Casagrande
PZ-3	22+39	230 U/S	495.2	451.92	43.28	25	Casagrande
PZ-4 <sup>1)</sup>	23+00	400 U/S	472.6	452.85	19.75	0	Casagrande
PZ-5 <sup>2)</sup>	24+58	18 D/S	583.0	?	?	60	Casagrande

NOTES: 1) Normal operating reservoir pool is elevation 478.

2) Four-inch-diameter flush joint casing was left in the borehole to a depth of about 71 feet.

Geotechnical Engineers Inc.

Project 87146  
June 5, 1987

TABLE 2 - PIEZOMETER INSTALLATION  
 NORTH SPRINGFIELD DAM  
 NORTH SPRINGFIELD, VERMONT  
 Delivery Order No. 1  
 Contract DACW33-87-0002

Piezometer No.	Approx. Station	Approx. Offset (ft)	Approx. Ground Elevation (ft)	Piezometer Tip Elevation (ft)	Approx. Tip Depth (ft)	Piezometer Tip Type
PZ-13	20+13	445 D/S	480	450.0	30	Casagrande
PZ-14	19+55	440 D/S	480	450.0	30	Casagrande

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 June 5, 1987

TABLE 3 - SUMMARY OF ESTIMATED COST  
PIEZOMETER INSTALLATION AND REPAIR  
Delivery Order No. 1  
Contract DACW33-87-0002

Drilling Contractor Costs

Townshend Dam	\$32,500
North Springfield Dam	8,400
A/E Services	<u>28,000</u>
Total	\$68,900

NOTE: See Appendix C for breakdown of Contractor costs and  
Appendix D for breakdown of A/E costs.

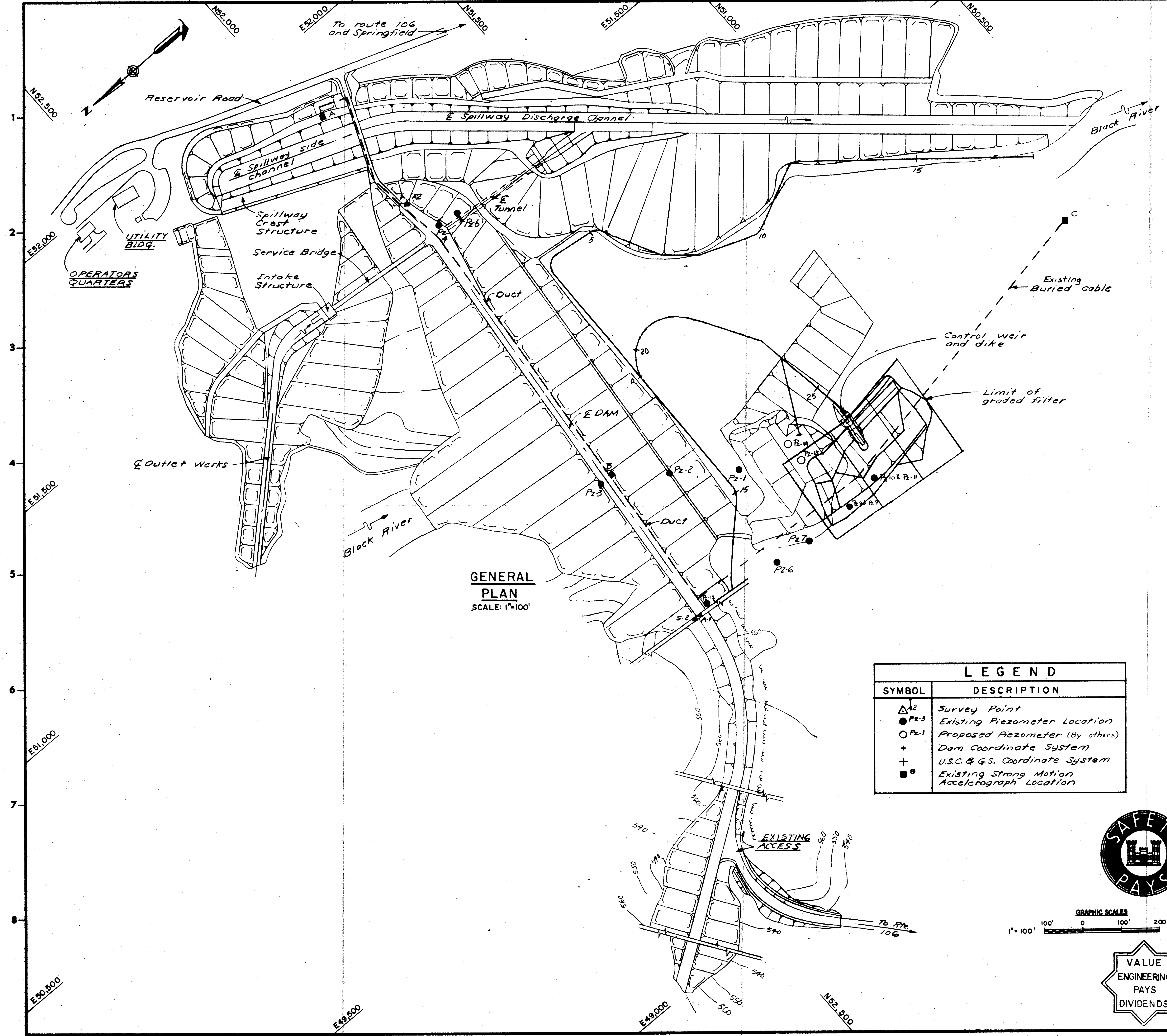
Geotechnical Engineers Inc.

Project 87146  
June 5, 1987



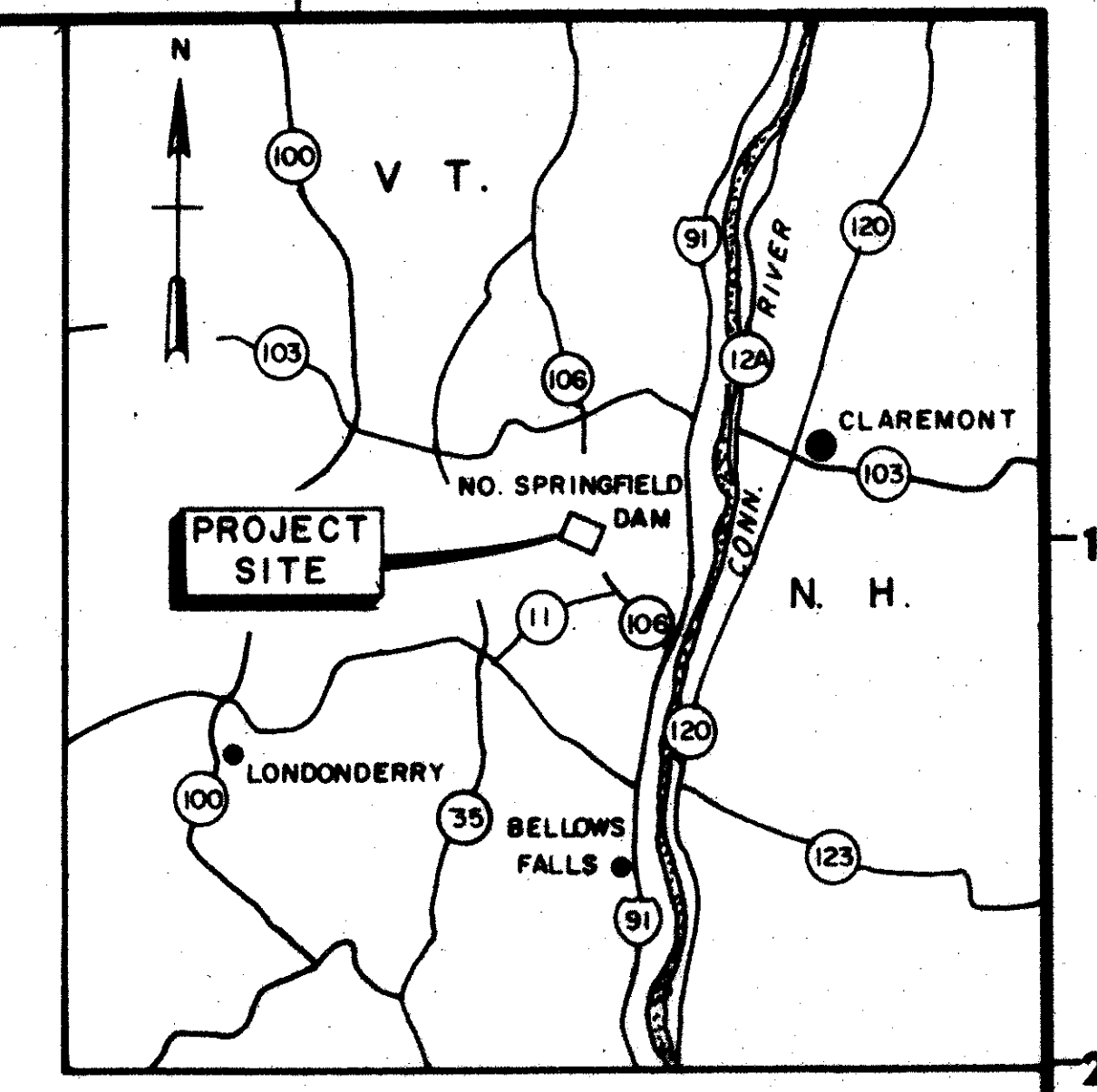
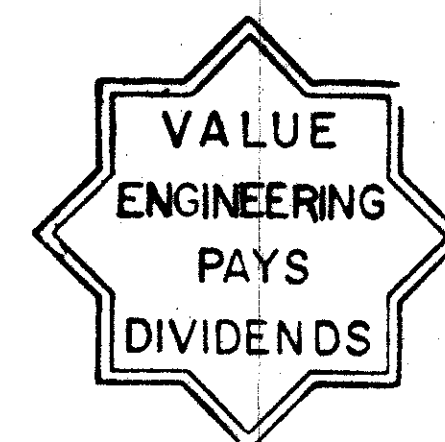
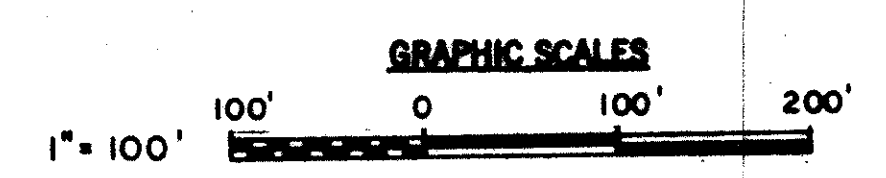
CORPS OF ENGINEERS

U. S. ARMY



GENERAL  
PLAN  
SCALE: 1"=100'

LEGEND	
SYMBOL	DESCRIPTION
Δ	Survey Point
● Pz-3	Existing Piezometer Location
○ Pz-1	Proposed Piezometer (By others)
+	Dam Coordinate System
+	U.S.C. & G.S. Coordinate System
■	Existing Strong Motion Accelerograph Location



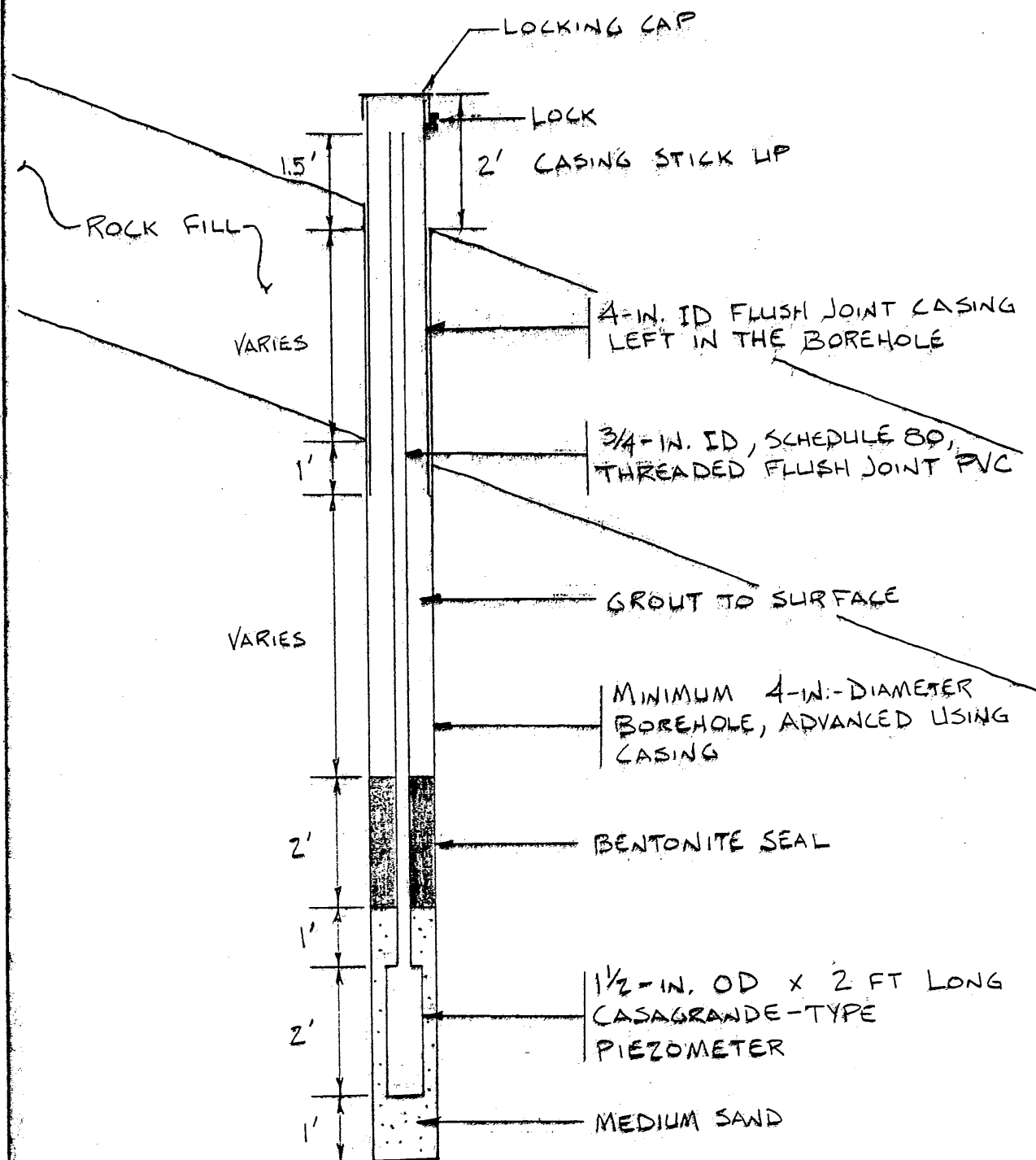
LOCATION MAP  
SCALE IN MILES  
0 5 10 15 20

NEW PIEZOMETER INSTALLATION  
AND  
EXISTING PIEZOMETER REPAIR


Project No. 87146 FIG. 2  
GEOTECHNICAL ENGINEERS INC. June 5, 1987

REVISION	DATE	DESCRIPTION	BY

DEPARTMENT OF THE ARMY NEW ENGLAND DIVISION CORPS OF ENGINEERS WALTHAM, MASS.		
WATER RESOURCES DEVELOPMENT PROJECT CONNECTICUT RIVER BASIN <b>NORTH SPRINGFIELD LAKE</b>		
BLACK RIVER		VERMONT
APPROVED	DATE	APR 1985
SPEC. NO. DACW33-85-8-0030 DRAWING NUMBER CON-259		
SHEET 1		



NOTE: FIGURE NOT TO SCALE.

U.S. Corps of Engineers Waltham, Massachusetts	Townshend Dam and North Springfield Dam, Vermont	CASAGRANDE-TYPE PIEZOMETER INSTALLATION
 GEOTECHNICAL ENGINEERS INC. WINCHESTER • MASSACHUSETTS	Project 87146	June 5, 1987 Fig. 3

APPENDIX A

NED-CE SCOPE OF WORK

SCOPE OF WORK  
FOR  
DESIGN AND ESTIMATE OF  
AUTOMATED INSTRUMENTATION SYSTEMS  
AT TOWNSHEND DAM, TOWNSHEND, VERMONT AND  
NORTH SPRINGFIELD DAM, NORTH SPRINGFIELD, VERMONT.

30 March 1987

## 1. PROJECT IDENTIFICATION

a. Authority. The authority for this work is set forth in Corps of Engineers Regulations ER 1130-2-417, Project Operation Major Rehabilitation Program and Dam Safety Assurance Program, 30 November 1980.

b. Project Sites. Townshend Dam, Townshend, VT; North Springfield Dam, North Springfield, VT.

## 2. PROJECT DESCRIPTION

a. Background. The U.S. Army Corps of Engineers, New England Division, is responsible for monitoring the performance of 31 dams throughout New England. The data derived from geotechnical instrumentation at the dam sites provides significant information about their performance. Reading these instruments by hand entails a considerable amount of time and expense. Consequently, New England Division is developing a program to automate the collection and storage of data from existing and future geotechnical instrumentation, starting with Townshend and North Springfield Dams in Vermont.

b. Requirement. Services required under this delivery order include preparation of designs and estimates for two automated systems (one for each site) which shall be capable of reading all on-site geotechnical instruments, storing the data on site, and electronically transmitting the data to the Geotechnical Engineering Branch in Waltham, Massachusetts. The total number of instruments to be read include 21 existing piezometers, seven future piezometers, two existing seepage measuring weirs, and two reservoir level gauges. The required services also include design of repairs to four existing inaccessible piezometers, and the estimate and design of seven new piezometers.

### c. Description of Dams.

(1) Townshend Dam is a rolled earth and rock fill dam located in Townshend, Vermont. The embankment is 1700 feet long with a maximum height of 133 feet. It has an inclined impervious core with adjacent pervious fill zones and rock fill outer shells. The dam has a crest elevation of 583 feet NGVD, a crest width of 25 feet, an upstream slope of 1V on 2 1/2H and a downstream slope of 1V on 2H. A 5-foot thick impervious blanket extends 500 feet upstream, protected at the west terrace slope by a 2 foot thick rock blanket on 12 inches of gravel bedding. The downstream west terrace slope is protected by a 3 foot thick rock blanket which extends 200 feet downstream from the embankment toe.

During the high impoundment at Townshend Lake in late May and early June of 1984, seepage pressures created boils in the gravel access road which runs downstream from the toe of the embankment parallel to the toe of the west terrace slope. The surface of the access road was found to be in a quick condition with raised bulges up to 5 inches above the normal level of the road. Additional boils were found on the slope between the access road and the toe of the west terrace slope. Remedial measures completed in 1970 consisted of a toe drain with graded filters to collect and control seepage flows. In 1984, the toe drain was functioning as designed but was partially bypassed by deep foundation underseepage.

A system of relief wells was installed along the toe of the west terrace slope and a portion of the adjacent toe of the embankment to relieve excess hydrostatic pressures and provide a controlled outlet for seepage.

There are eleven existing Casagrande piezometers in the downstream terrace. One boring drilled by conventional methods in 1985, located on the crest of the dam, was stopped because of continuous drilling fluid loss in the rock fill zone. The casing was left in the hole with plans to complete the boring with special equipment at a later date and to install a Casagrande piezometer. There are four pneumatic type piezometers in the upstream blanket which have become inoperable and should be replaced.

(2) North Springfield Dam is a random earth and rockfill dam located in North Springfield, Vermont. The embankment is 2940 feet long with a maximum height of 120 feet above invert elevation. The crest width is 30 feet and is at elevation 570 feet NGVD, which is 24.5 feet above spillway crest. The embankment slopes vary from 1V on 2H to 1V on 4H.

The dam has a history of seepage and remedial repair work. In 1969, impounded snow-melt waters reached elevation 531 feet MSL, stage 78.8 feet, 15 feet below spillway crest. Seepage emerged at the downstream toe carrying appreciable amounts of silt and sand which caused the rock fill berm to settle. Remedial repair work completed in 1970 consisted of various filter blankets, piezometers, and a seepage measuring weir. The system functioned adequately until 1984. In May and June 1984, storm runoff was impounded up to stage 76.5 feet (elevation 527 feet MSL) which was about 18 feet below spillway crest and 68 feet above the downstream seepage pool surface. Heavy seepage emerged at several locations along the downstream right abutment above the seepage pool and at least one piping channel started to develop in this area. Remedial measures for seepage control were again required in 1985. The measures included a graded filter system with stone protection along the right abutment and the installation of five piezometers.

Piezometers were installed at various times to monitor seepage. Five open-type piezometers (PZ-1 through PZ-5) were installed in the foundation of the dam embankment during the 1970 construction to monitor pore pressures during operation of the reservoir. Also (in 1970), two piezometers (PZ-6 and PZ-7) were installed in the downstream right abutment slope behind the filter layers with their tips in the terrace foundation pervious zone. In 1985, five open-type piezometers were installed to monitor seepage from the pervious right abutment terrace deposit. Four of the five piezometers were installed in the area of the 1985 remedial work; one was installed on the downstream edge of the dam crest at about Station 22+00. The 6-inch casings used for two of the piezometers in the area of the remedial work are currently sticking up over 13 feet above the ground surface and cannot be read. There are a total of twelve existing piezometers at North Springfield Dam and two more are planned.

A permanent weir with training dike was installed at North Springfield as part of the 1970 remedial work to measure seepage emerging in the location of the original river channel. The plywood V-notch has been damaged by beavers. Installation of a replacement weir, constructed of stainless steel, is planned in the near future.

### 3. ITEMS FURNISHED BY THE GOVERNMENT

- Attachment 1. Plan of Townshend Dam locating piezometers.
- Attachment 2. Plan of North Springfield Dam locating piezometers.
- Attachment 3. Piezometer data tables.
- Attachment 4. Drill logs of abandon hole (FD85-8) and inoperable pneumatic piezometers (PZ-1, PZ-2, PZ3 & PZ-4) at Townshend Dam.

### 4. A-E SERVICES

a. General. The contractor shall design and estimate two automated instrumentation systems to gather and record geotechnical data from instrumentation at two existing Corps of Engineers dams; Townshend Dam and North Springfield Dam. The systems shall provide for automated readings and data transmittal from instruments at the two dams and the instruments shall include the piezometers listed in Attachment 3, seven piezometers to be installed, seepage measuring weirs and the reservoir level gauges. All these instruments and level gauges are to be automatically read every 8 hours with all readings being taken as close to the same time as possible (i.e. 8 a.m., 4 p.m., and 12 midnight). The readings are then to be automatically transmitted (by the GOES satellite at Townshend Dam and by telephone line at North Springfield Dam) at intervals to be selected by the Corps, to a Government owned IBM AT compatible microcomputer. The last 50 sets of readings shall be stored in the equipment provided so that these prior readings can be accessed via a RS-232C port connector using portable hand-held data storage units. The equipment electronics shall be fully equipped with sufficient nonvolatile memory to support all required logic, programming, and monitoring requirements, and in addition, a minimum of 50 sets of data.

#### b. General Requirements Concerning Automated System Design.

- (1) Manual reading of automated instruments must still be possible after the automation system is in place without requiring disassembly of the automation system.
- (2) The automation equipment shall provide for local automatic operation in the event of failure of the data transmittal system.
- (3) Automation equipment shall be fully compatible with existing piezometer installations and facility equipment.
- (4) System electronics shall provide time tagging of scanned data, including month, day, and year. Days shall be reported to two decimal places to account for the time of day (day as 12.75 + 6 p.m. on the twelfth). Timing accuracy shall not drift greater than 1 minute/year.
- (5) System electronics shall be provided with a watch dog timer; in the event of power failure, the system shall start up and resume the specified operation procedures without any reprogramming, after normal power supply is restored.



(6) A backup supply of power, capable of supplying all required power to fully operate the automated data reading and transmittal system for not less than 10 consecutive days, shall be included in the system design.

(7) Instrument readings taken automatically must be output in some manner such that a person watching the automation equipment on-site would know what instrument is currently being read and what the current reading is.

(8) Though all instruments are to be initially set up to be automatically read every 8 hours, the time interval between readings shall be programmable with the minimum programmable time interval being no greater than 4 hours and the maximum programmable time interval being no less than 24 hours.

(9) The system shall be capable of satisfactory long-term performance in severe climatic conditions, including temperatures ranging from -20 degrees to 120 degrees Fahrenheit and relative humidity ranging from 0 to 98 percent.

(10) The system shall be designed such that potential future additions, servicing, maintenance, and repair of the system can be accomplished readily and in a straightforward manner.

(11) All cable used shall be 100 percent shielded cable.

(12) All cable runs shall be buried at least 24 inches below the ground surface, with 6-inch wide yellow "caution" tape installed 6 inches above the cable. Cable shall be installed in conduit where it is less than 24 inches below the ground surface, as it is brought into buildings or to terminal pipes. Cable running in metal conduit need only be buried 6 inches below the ground surface. The requirements for cable runs apply as well for tubing runs.

(13) The accuracy of the automation system relative to reading and transmitting data shall be as follows:

Open standpipe piezometers. -  $\pm 0.1$  foot  
Seepage Weir Gauge -  $\pm 0.01$  foot  
Reservoir level gauge -  $\pm 0.01$  foot

(14) The system should use a microcomputer to act as the network monitor station to collect, process, display and produce a hard copy of the data at the project office. This network monitor station must also be capable of performing a quality control check of instrument readings, respond to a preset threshold level, interface with existing project hardware and software applications and have the ability to be queried from NED or other remote location.

(15) A backup communication link to NED should be provided for the data transmission. Transmitter equipment for transmitting data to the data collecting/processing equipment shall be in compliance with all applicable requirements and regulations.



(16) Protection and location of all hardware on-site shall be discussed with the project manager of both dams. If needed, construction of additional instrumentation shelters shall be included in the design of the automated system.

c. Requirements Concerning Connections to Electrical Power.

All electrical work shall be in conformance with the National Electrical code. The standard for satisfactory connections to existing electrical power, upon which approval of plans will be based, will be in conformance with the National Electrical Code and provision of installations comparable in quality to the existing facilities.

d. New Piezometers. The contractor is required to design and estimate four new piezometers at Townshend Dam to replace the inoperable pneumatic piezometers in the upstream blanket (including conduit and anchors to resist ice action). The new piezometers shall be located within a 5 foot radius of the existing piezometers with the new tip at the same elevation as the existing tip and shall be compatible with the design automation system. Also required are the design and estimate two new piezometers to be installed along the downstream toe of the 1985 remedial repair at North Springfield Dam. The location of these piezometers is provided by the Government in Attachment 2. Also required are the design of repairs to the four piezometers (two standpipes) in the 1985 remedial repair area on the downstream slope at North Springfield (which currently have 13+ feet of casing sticking up in the air), and design of drilling techniques to continue an abandon hole on the crest at Townshend Dam. A copy of the drilling log for the abandon hole and the piezometer logs for the inoperable and inaccessible piezometers are included in attachment 4.

e. Geotechnical Report. A geotechnical report shall be prepared and submitted which presents the designs of the automated instrumentation systems, the design and location of new or replacement piezometers and the design repairs for exiting non-functioning piezometers. The final report shall contain but not be limited to the scope of investigation, a discussion of results, presentation of designs and repair recommendations, plans and specifications suitable for contract issue, a summary of daily field activities, and safety reports covering the time spent in the field. Included shall be a list of equipment and products with specifications provided for procurement action.

5. COORDINATION.

Liaison will be maintained for the duration of the contract through frequent telephone contacts and meetings held at the request of the point of contact, Mr. Paul L'Heureux.

6. COMPLETION SCHEDULE.

Services under this delivery order shall start on or before five days from the receipt of the notice to proceed. Duration of work is estimated to be 15 work days. Two copies of the geotechnical report shall be submitted in draft format for review by the Government no later than 30 calendar days after receipt of the Notice to Proceed.

7. GOVERNMENT REVIEW.

The Government review will take approximately 10 calendar days from receipt of draft report. Three copies of the final geotechnical report shall be submitted no later than 7 calendar days after your receipt of Government reviewed draft report including the action taken on possible comments.

8. QUALITY CONTROL.

Your attention is invited to the Contract General Provisions, "Responsibility of the Architect-Engineer" and "Design Within Funding Limitations". You will be held responsible for the quality of the maps submitted and for all damages caused the Government as a result of your negligence in the performance of any services furnished under the contract.

Although submissions required by your contract are technically reviewed by the Government, it is emphasized that your work must be prosecuted using proper internal controls and review procedures. The letter of transmittal for each submission which you make shall include a certification that the submission has been subjected to your own review and coordination procedures to ensure (a) completeness for each discipline commensurate with the level of effort required for that submission, (b) elimination of conflicts, errors and omissions, and (c) the overall professional and technical accuracy of the submission. Documents which are significantly deficient in any of these areas will be returned to you for correction and/or upgrading prior to our completing our review. Contract submission dates will not be extended if a resubmission of draft material is required for this reason. It is requested that you indicated in writing in your fee proposal letter your cognizance of this requirement and that your firm and your associates, if any, have the professional competency and technical expertise necessary to accomplish this project in a satisfactory manner.

APPENDIX B  
TECHNICAL SPECIFICATIONS

TECHNICAL SPECIFICATIONS  
INSTALLATION OF PIEZOMETERS  
TOWNSHEND DAM  
TOWNSHEND, VERMONT  
AND  
NORTH SPRINGFIELD DAM  
NORTH SPRINGFIELD, VERMONT

Delivery Order No. 1  
Contract No. DACW33-87-D-0002

GEI Project No. 87146

# TECHNICAL SPECIFICATIONS

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### 1.1 General

The Contractor's work includes installing five Casagrande-type piezometers at Townshend Dam in Townshend, Vermont and two Casagrande-type piezometers at North Springfield Dam in North Springfield, Vermont. Split-spoon samples will be required every 5 feet below the rockfill for each piezometer borehole to the depth required for installing the piezometer.

The Contractor's work also includes lowering the height of two existing standpipes with two Casagrande-type piezometers in each standpipe at North Springfield Dam.

### 1.2 Townshend Dam

The location of the five piezometers at Townshend Dam, PZ-1 through PZ-5, are shown in Fig. 1. The required piezometer tip elevations and estimated tip depths below ground surface are included in Table 1.

Piezometers PZ-1 through PZ-4 will be installed from the upstream slope adjacent to four inoperable pneumatic piezometers. The Casagrande-type piezometers shall be located within a 5-foot radius of the existing pneumatic piezometers. Piezometers PZ-1 through PZ-3 are located on a 2.5H:1V rockfill slope and will probably require construction of a working platform. Estimated depth of the rockfill at each piezometer location is included in Table 1. Piezometer PZ-4 is located in the impervious upstream blanket. There is about 5 to 6 feet of water at this location at the normal operating reservoir pool. A barge will be required to install the piezometer.

Piezometer PZ-5 is located on the crest of the dam and is probably accessible by a truck-mounted drill rig. The borehole for piezometer PZ-5 was started in 1985 and stopped at a depth of 95.5 feet because of continuous loss of drilling fluid in the rockfill zone. Four-inch-diameter casing was left in the borehole to a depth of about 71 feet inside of 6-inch-diameter casing to an unknown depth. The boring for installation of piezometer PZ-5 shall be continued into the foundation of the dam below the rockfill to a depth determined by the Geotechnical Engineer in the field.

### 1.3 North Springfield Dam

The locations of the two piezometers at North Springfield Dam, PZ-13 and PZ-14, are shown in Fig. 2. The required piezometer tip elevations and estimated tip depths below ground surface are included in Table 2.

The piezometers will be installed along the downstream toe filter, just upstream of the seepage pond. The piezometer locations are on level ground and accessible by a truck-mounted drill rig. The top part of the boring will be through rockfill of unknown thickness.

Two existing standpipes enclosing two Casagrande-type piezometers each, PZ-8 and 9 and PZ-10 and 11, currently stick up above the ground surface about 19.5 feet and 12.5 feet, respectively. The standpipes consist of 6-inch-diameter flush joint casing and are located on a 1.5H:1V crushed stone slope in the 1985 downstream remedial repair area. About 40 feet west of the standpipes, the ground is fairly level at the top of the slope and is accessible for a crane.

### 2.1 General

The Contractor shall furnish all labor and materiel necessary for carrying out the work described in these specifications.

### 2.2 Equipment Requirements

The Contractor shall transport to the site, mobilize, and continuously utilize all materiel necessary to make the borings, install Casagrande-type piezometers, and repair existing piezometers and standpipes. All such items shall be manned and maintained in a condition acceptable to the Geotechnical Engineer from the commencement until the completion of the work.

The borings shall be made using heavy-duty rotary drilling equipment of a size and type designed to drill holes of the sizes and to depths required in these specifications. Drilling units shall be equipped with a hydraulic feed, or a hand-feed unit may be used if approved by the Geotechnical Engineer. Drilling fluids other than water must be used when deemed necessary by the Geotechnical Engineer, or may be used in some cases by the Contractor upon specific approval by the Geotechnical Engineer for each boring. Provision for recirculation of drilling fluid shall be provided. Precautions shall be taken to minimize spillage of any fluids or debris.

At the end of all work, or when relieved by the Geotechnical Engineer of the need for the items covered in this section, the Contractor shall demobilize such facilities and restore any spaces used to their former condition.



ITEM NO. 3                      MOVES AND SETUPS

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3.1 General

The Contractor shall take full responsibility to set up the necessary equipment at the correct location of the piezometers.

During boring operations, if the casing is broken off at any depth for any reason, necessitating an additional boring(s), it will be the responsibility of the Contractor to make any additional move(s) and to make any boring(s) or portion of boring(s) to the same depth that was accomplished in the initial boring. It is the responsibility of the Contractor to advance the boring to the full depth required to install the piezometer tip at the design elevation.

#### 4.1 General

The borings shall be advanced using flush-joint casing having a minimum 4-inch diameter. The boring for piezometer PZ-5 at Townshend Dam will be allowed a minimum 3-inch-diameter casing. Unless otherwise approved by the Geotechnical Engineer, the length of open borehole below the bottom of the casing shall not exceed 6 inches. The boring shall be advanced to about 1 foot below the required piezometer tip elevation (Figs. 1 and 2).

The Contractor should anticipate difficult drilling at both dams and plan on using two to three different sizes of casing telescoped inside of each other to advance the boring to the required depth for piezometer installation.

The Contractor may choose to advance the boring through the rockfill zone using down-hole hammer techniques approved by the Geotechnical Engineer.

Split-spoon samples shall be taken at 5-foot intervals below the rockfill in each boring.

#### 4.2 Advancing the Boring for Soil Sampling

Each boring shall be advanced below the rockfill by using a tricone roller bit or chopping bit. Drill fluid shall be forced down through the drill pipe and out through ports in the bit to carry the cuttings up and out of the boring. Water ports in the bit shall be so arranged that there is no jetting action of the drill water ahead of the bit, and the minimum amount of water necessary to carry away the cuttings shall be used. In no case shall a bottom-discharge bit be permitted. The process of jetting through an open-tube sampler and then sampling when the desired depth is reached shall not be permitted.

Initially, water may be used as a drill fluid. However, if requested by the Geotechnical Engineer because of conditions encountered, the Contractor shall use Revert drilling mud or equivalent.

Upon request of or approval by the Geotechnical Engineer, the boring may be advanced by driving the casing into the soil and then cleaning out to a maximum depth of 6 inches below the bottom of the casing using the bits described above.

The water level in the boring shall be maintained at the top of the casing at all times during the boring operation.

If boulders are encountered in soils above the desired depth of a boring, the Geotechnical Engineer may require the Contractor to drill through the boulders. The Contractor may use a roller bit or a rock core bit to drill through the boulders.

As the boring is advanced, special care shall be taken to note and record the depth where drilling water is lost, if this occurs, or any other details about the progress of the boring. In each boring the driller shall record the water level prior to installing the Casagrande piezometers and whenever possible prior to the start of each day's work.

#### 4.3 Split-Spoon Samples

The purpose of this sampling method is to determine the physical properties, arrangement, and thickness of the various soil strata as they exist in the ground. It is necessary to locate and record the elevation at which any change in stratification occurs and to obtain samples truly representative of the material, including its natural water content, comprising each stratum as it exists in the ground. Each sample shall be sealed as soon as it is removed from the ground, and packed so that it will reach the laboratory in as near as possible the condition in which it was removed from the ground, without loss of water by evaporation or damage by freezing, breakage of containers, or other disturbance in transit.

Samples shall be taken using a 1-3/8-inch-I.D. by 2.0-inch-O.D. split-barrel sampler, as described in Fig. 1 of ASTM Designation D1586. The bottom of sampler shall be sharpened to form a cutting edge at its inside circumference. The cutting edge shall be maintained in good condition and replaced as required by the Geotechnical Engineer. The sampler shall be fastened to its drive pipe by a connection embodying a check valve which will permit the ready escape of water trapped above the sample as the sampler is driven down into the soil, but which will close as the soil sample and sampler are withdrawn, thus preventing the development of hydrostatic pressure on top of the soil during withdrawal. The check valve should be inspected at frequent intervals to ensure that it remains in satisfactory working order. The Contractor shall install a perforated section of drill rod behind the sampler to ensure that the drilling fluid does not collect in the drill rods while the sampler is being withdrawn. A minimum of six (6) holes of 0.5-inch-diameter

should be present over a distance of two (2) feet immediately above the sampler.

Before the start of the drilling operations, the Contractor shall furnish the Geotechnical Engineer with a complete description of the sampler, giving inside and outside diameters, length of the inside of the barrel, and check valves used.

The drive weight assembly shall consist of a 140-lb weight, a driving head, and a guide permitting a free fall of 30 inches. A certificate will be provided to the Geotechnical Engineer indicating the 140-lb weight has been recently weighed and this information properly recorded. Special precautions shall be taken to ensure that the energy of the falling weight is not reduced by friction between the drive weight and the guides. The drive head assembly shall be painted with fluorescent paint above the 30-inch mark to permit the Geotechnical Engineer to observe the length of free fall.

In all borings, split-spoon samples shall be taken at 5-foot intervals through the soil profile below the rockfill zone unless otherwise directed by the Geotechnical Engineer. The use of a 2-foot-long split-spoon sampler will be allowed.

The following procedures shall be used in taking split-spoon samples:

The boring shall be cleaned out to the sampling elevation using the equipment that will ensure that the material to be sampled is not disturbed by the operation. Where casing is used, it shall not be driven below the top of the sampling elevation. The drill bit shall be withdrawn very slowly to prevent loosening of the soil around the hole. The water level in the boring shall be kept at the top of the casing at all times during the boring operation.

With the sampler resting on the bottom of the hole, the sampler shall be driven with blows from the 140-lb hammer falling 30 inches until either 18 inches have been penetrated or 100 blows have been applied over a 6-inch drive. The rope used to lift the 140-lb weight should be made of tightly wound hemp or other approved rope comprised of natural fiber. The rope should be wrapped twice around the cat-head drum while the number of blows for each 6 inches of penetration on the split-spoon sampler is being recorded.

For each sample the number of blows required to effect each 6 inches of penetration or fraction thereof shall be recorded. The first 6 inches is considered to be a seating drive. The sum of the number of blows required for the second and third 6 inches of penetration is termed the "standard penetration resistance." If the sampler is driven less than 18 inches, the standard penetration resistance is that for the last one (1) foot of penetration. (If less than one (1) foot is penetrated, the log shall state the number of blows and the number of inches penetrated.)

The sampler shall be withdrawn very slowly so that no appreciable head of drilling fluid will exist inside the rods, and so that there will be no appreciable suction created at the bottom of the sampler that will tend to cause loss of sample.

After the sampler is brought to the ground surface, the sample shall be carefully removed. The top of the sample will generally be disturbed due to the cleaning out of the casing and shall be discarded. Representative samples of each different type of soil shall be retained. Each part shall be placed immediately in separate airtight containers without ramming. Samples that hold together shall be placed in clear plastic bags before they are inserted in the container. The caps of the containers shall be sealed immediately or at the end of each shift by dipping into liquid microcrystalline wax. Each container shall be labeled immediately with the boring number, sample number, its depth below ground surface at the boring, and all blowcounts. If more than one type of soil is found in the sampler, for instance, part sand and part clay or alternating layers of such soils, the thickness and description of the individual layers shall be recorded in the log and representative samples of each soil type placed in separate containers. The sample number, depth, and blowcounts given on each container shall correspond to that portion of the sample contained therein. A jar shall be labeled and waxed for each sample attempt. If there was no recovery, it should be noted on the jar.

If a sample is not recovered or is found unsatisfactory as to size or condition, a second attempt shall be made to obtain a satisfactory sample before sinking the casing to a lower depth. Overdriving the spoon to ensure sample recovery will be permitted only upon approval by the Geotechnical Engineer in each case.

Sample containers shall be of a size to receive comfortably the standard sample. (A 2-inch-I.D. by 5-inch-long, wide-mouth flat-sidewall jar is satisfactory.) Containers

which are too large and permit undesirable disturbance of the sample in transit shall not be used. The samples shall be shipped to the laboratory or turned over to the Geotechnical Engineer's representative at the site, on a regular basis, as directed by the Geotechnical Engineer. Temporary storage shall be provided by the Contractor at the site, as necessary.

#### 4.4 Packing and Shipping Samples

##### a. Split-Spoon Samples

The airtight containers used to store the split-spoon samples shall be packed in cardboard boxes designed for this purpose. Wherever possible, only samples from one boring should be placed in each box. These boxes should be handled carefully to prevent breakage of the airtight containers during shipment and to prevent freezing or excessive heating of the samples.

##### b. Shipment of Samples

Unless otherwise directed by the Geotechnical Engineer, the split-spoon samples and core samples shall be shipped by the Contractor to the office of Geotechnical Engineers Inc., 1021 Main Street, Winchester, MA 01890, Attention: Mr. Stephen L. Whiteside. The samples should be protected from freezing temperatures and excessive heat.

#### 4.5 Records

##### a. Boring Logs

One copy of the driller's field logs shall be given to the Geotechnical Engineer not later than noon of the day following completion of each boring. Typed copies of each boring log shall be forwarded to Stephen L. Whiteside, Geotechnical Engineers Inc., 1021 Main Street, Winchester, MA 01890. Two copies of the boring logs shall reach this address not more than ten (10) days after completion of each boring. Each log shall contain the following information:

(1) Boring number, date boring was commenced and completed, the Geotechnical Engineer's job number, and the driller's name.

(2) Elevation of the ground surface and the coordinate at the boring.

(3) Depth below ground surface or true elevation of each stratum of soil or rock encountered.

(4) Brief description of each stratum of soil or rock encountered, including the character of the material and its degree of compactness.

(5) Depth below ground surface of the groundwater table and the length of the time after completion of the boring when measured, as well as a record of the daily water level readings, time when taken, and the casing depth at the time.

(6) Depth at which drilling fluid was lost in either soil or rock, if such loss occurs, amount of loss and range of depth over which loss occurred. Similar data shall be recorded if artesian conditions occur.

(7) Depth at which samples were taken.

(8) All blowcounts recorded during the standard penetration test.

(9) Comments by the driller or field foreman covering any special conditions that were encountered.

(10) Penetration and recovery of all soil samples.

(11) Data concerning the installation of piezometers.

### 5.1 General

Piezometers of the Casagrande-type will be installed by the Contractor. The location of the piezometers at Townshend Dam, PZ-1 through PZ-5, is shown in Fig. 1, and the location of the piezometers at North Springfield Dam, PZ-13 and PZ-14, is shown in Fig. 2.

### 5.2 Materials

The following materials will be required for installation of a Casagrande-type piezometer and shall be furnished by the Contractor:

- a. CASAGRANDE-TYPE PIEZOMETER - consisting of a porous plastic or porous alundum tip that is 1.5-inch diameter and about 2 feet long, as supplied by the Piezometer Research and Development Corporation, 33 Magee Avenue, Stamford, Connecticut, or approved equivalent.
- b. PIEZOMETER RISER PIPE - 3/4-inch-inside diameter, Schedule 80, flush joint PVC pipe with threaded joints, sealed to one end of the porous tip and extended 18 inches above the ground surface.
- c. Clean, uniform, MEDIUM SAND - <3% passing 200 mesh sieve, coefficient of uniformity = 2.5, grain size approximately 0.4 to 2 mm or standard Ottawa sand (ASTM Designation C190).
- d. BENTONITE BALLS - Volclay KWK No. 33 or equal.
- e. PEA GRAVEL - 1/4- to 3/8-inch subrounded, uniformly graded gravel.
- f. LOCKING SURFACE CASING - Part of the 4-inch-diameter flush joint casing used to advance the borehole will be left in the borehole, as determined by the Geotechnical Engineer in the field, as the protective casing. The casing shall be topped with a locking cap slightly larger than the outside diameter of the casing, as shown in Fig. 3. The Contractor will be required to weld a strip of metal with a 1/2-inch-diameter hole in it to the side of the casing to lock the cap to the casing.



g. CEMENT-BENTONITE GROUT shall be a mixture of portland cement, pulverized bentonite, and water. The mixture shall contain 10 gallons of water and 2 lbs of bentonite for each 94 lb sack of cement. The portland cement shall conform to the requirements of ASTM Designation for Type I or Type II cement. Bentonite shall be a natural Wyoming sodium bentonite containing no additive, ground to pass a No. 200 sieve. The grout shall be mixed in a manner resulting in a smooth slurry. The proportions of cement and bentonite may be varied by the Geotechnical Engineer in the field.

Materials to be used must be approved by the Geotechnical Engineer.

### 5.3 Installation

Casagrande-type piezometers will be installed in existing 4-inch-diameter cased borings. Installation may require backfilling and extraction of casing to the desired piezometer tip elevation. Backfilling will be as described below.

When the boring has been backfilled or cased to the desired elevation, the Contractor shall clean out the rest of the hole by flushing it with a side discharge bit until the water running out of the casing is clear and void of any cuttings.

The water level in the borehole shall be maintained at the top of the casing at all times during the installation process unless otherwise directed by the Geotechnical Engineer.

The installation of the Casagrande-type piezometer shall proceed as follows:

- a. Pour enough MEDIUM SAND into the casing to equal one foot of thickness and wait until it settles to the bottom of the borehole. Bump out the casing an amount equal to the thickness of sand placed.
- b. Lower the Casagrande piezometer and riser pipe into the borehole and allow it to rest on the sand cushion described in a. above. The riser pipe shall extend 18 inches above the ground surface. It must be noted that special care should be taken to ensure that all connections are watertight.

c. Pour MEDIUM SAND into the borehole between the casing and the riser pipe in increments of 6 to 12 inches, bumping back the casing after each increment. Continue this procedure to a height above the piezometer tip, as specified in the field by the Geotechnical Engineer; agitate and allow the sand to settle.

d. Place a 24-inch-thick seal consisting of alternating 3-inch-thick layers of BENTONITE BALLS and PEA GRAVEL. Tamp each layer of the seal firmly into place with a tamper approved by the Geotechnical Engineer.

e. Backfill the remainder of the borehole to the ground surface with CEMENT-BENTONITE GROUT. The cement-bentonite grout shall be placed using tremie techniques through a 3/4-inch black flexible PVC pipe or approved equivalent. The end of the pipe should be completely plugged and 1/2-inch discharge holes drilled in the pipe wall for the bottom 1 foot of the pipe. The pipe shall be lowered to the bottom of the hole and grout pumped until grout is observed flowing out the top of the casing. Grout shall continue to be pumped as the grout pipe is withdrawn from the borehole.

f. The remaining casing shall then be pulled back to the bottom of the rockfill zone and left in place to protect the piezometer riser pipe from the rockfill. As casing is removed from the borehole, grout shall be added to maintain the grout at the desired level. The grout shall be allowed to set overnight. The next day the depth to the top of the grout shall be checked. If the top of the grout is more than 2 feet below the ground surface, additional grout shall be added.

g. Casing shall be added or cut off so that it sticks up about 2 feet above the ground surface. A locking cap shall be placed on top of the surface casing to prevent damage to the piezometers. A strip of metal with a 1/2-inch-diameter hole in it shall be welded to the surface casing to lock the cap to the surface casing.

h. At Townshend Dam the surface casing for piezometer PZ-4 shall stick up about 2 feet above the normal operating reservoir pool.

i. The Contractor shall test the operation of each piezometer under the observation of the Geotechnical Engineer.

### 6.1 General

The Contractor shall provide an accurate reference elevation near the borehole prior to advancing the boring to the desired depth and installing the piezometers.

### 7.1 General

Repairs for lowering the existing piezometers and standpipes at North Springfield Dam will be performed by the Contractor. The location of the four existing piezometers, PZ-8 and 9 and PZ-10 and 11, enclosed in two standpipes is shown in Fig. 2.

### 7.2 Procedure

The anticipated procedure for repairing the existing piezometers and standpipes is described below. The procedure may be modified in the field subject to the approval of the Geotechnical Engineer.

a. A crane will be used to support the top of the casing at all times during the work and to finally remove the upper portion of the standpipe.

b. Two 12-inch-high holes should be cut on opposite sides of the standpipe about 6 inches above the lowest exposed joint in the standpipe. The holes should be wide enough to provide access for cutting the piezometer riser pipes. In addition, enough steel pipe should be left to support the weight of the standpipe above with the aid of the crane. The Contractor should be careful not to cut the two 3/4-inch-diameter PVC riser pipes inside of the standpipe when cutting these holes.

c. Remove as much sand as possible from inside the standpipe above the cut holes by hammering the outside of the standpipe or jetting water inside the standpipe.

d. Cut both PVC riser pipes inside the standpipe in two places. Before removing the cut section of PVC, cover the top of both piezometer riser pipes to prevent sand that may still be in the top of the standpipe from falling in the piezometer.

e. Cut the remainder of standpipe still connected about 6 inches above the lowest exposed joint and remove the pipe section using the crane.

f. Remove sand from inside the remaining portion of the standpipe to a depth sufficient to be able to remove the 6 inches of standpipe above the joint using wrenches and without damaging the piezometers.

g. After the 6-inch-long section of standpipe has been removed, cut the PVC riser pipe flush with the top of the standpipe joint and screw the 6-inch-long section of standpipe back on so the PVC riser pipe will be 6 inches below the top of the standpipe.

h. The standpipe shall be covered with a locking cap slightly larger than the outside diameter of the standpipe, as required for the new piezometers in Section 5.2. A strip of metal with a 1/2-inch-diameter hole in it shall be welded to the standpipe for locking the cap to the standpipe.

## APPENDIX C

### ESTIMATED COSTS FOR DRILLING CONTRACTOR

Table C1 - Estimate of Contractor Costs for Piezometer  
Installation, Townshend Dam, Townshend, Vermont

Table C2 - Estimate of Contractor Costs for Piezometer  
Installation, North Springfield Dam, North  
Springfield, Vermont

TABLE C1 - ESTIMATE OF CONTRACTOR COSTS FOR PIEZOMETER INSTALLATION  
TOWNSHEND DAM, TOWNSHEND, VERMONT  
Delivery Order No. 1  
Contract DACW33-87-0002

ITEM NO	SUPPLIES/SERVICES	UNIT	UNIT PRICE	ESTIMATED QUANTITY					TOTAL	ESTIMATED COST	
				PZ-1	PZ-2	PZ-3	PZ-4	PZ-5			
3.	SURVEYING										
3.1	Mobilization and Demobilization	JOB	180.00						1	180.00	
3.3	Mileage from/to Contractor's equipment storage site located in Manchester, NH	MI	0.35						200	70.00	
3.4	Survey crew and equipment	DAY	440.00						1	440.00	
6.	MOBILIZATION AND DEMOBILIZATION ONE DRILL RIG, CREW AND AUXILIARY EQUIP										
6.1	Mobilization and Demobilization	JOB	700.00	1					1	2	1400.00
6.3	Mileage from/to Contractor's equipment storage site located in Manchester, NH	MI	1.15						200	230.00	
6.5	Standby time/on site moves	HR	75.00	16	16	16	24	8	80	6000.00	
10.	FLOATING PLANT, ATTENDANT VESSEL, CREW AND EQUIPMENT										
10.1	12 ft. boat	DAY	55.00				5		5	275.00	
10.3	Operator for 12 ft boat	DAY	185.00				5		5	925.00	
10.7	Mobilization and Demobilization for 320 square foot float	JOB	950.00				1		1	950.00	
10.7A	On-site moves	JOB	600.00				1		1	600.00	
13.	DRIVE SAMPLE BORING (SPT) WITHOUT CASING										
13.1	0-30 ft. depth	EA	13.00	4	1		5		10	130.00	
13.2	31-50 ft. depth	EA	16.00	4	4	3			11	176.00	
13.3	51-100 ft. depth	EA	20.00	10	3			2	15	300.00	

TABLE C1 - ESTIMATE OF CONTRACTOR COSTS FOR PIEZOMETER INSTALLATION  
TOWNSHEND DAM, TOWNSHEND, VERMONT  
Delivery Order No. 1  
Contract DACW33-87-0002

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ITEM NO	SUPPLIES/SERVICES	UNIT	UNIT PRICE	ESTIMATED QUANTITY					TOTAL	ESTIMATED COST
				PZ-1	PZ-2	PZ-3	PZ-4	PZ-5		
18.	DRIVING AND PULLING CASING									
18.1	BX, NX size	LF	18.00					60	60	1080.00
18.2	HX and 6-inch size	LF	28.00	91	40	19	5		155	4340.00
19.	DRIVING CASING AND LEAVING IN PLACE									
19.5	HX casing	LF	18.00	6	21	26	15		68	1224.00
20.	CASING AND PIPE									
20.3	HX casing	LF	25.00	8	23	28	22	2	83	2075.00
24.	PIEZOMETER									
24.1	Casagrande type, 0-50 ft. depth	LF	15.00	50	50	44	20	50	214	3210.00
24.2	Casagrande type, over 0-50 ft.	LF	17.00	46	10			80	136	2312.00
	PLATFORM CONSTRUCTION									
	Labor	HR	75.00						16	1200.00
	Materials	EA	1000.00						1	1000.00

Contingency (15%) 4217.55

TOTAL ESTIMATED COST 32334.55

Geotechnical Engineers Inc.

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TABLE C2 - ESTIMATE OF CONTRACTOR COSTS FOR PIEZOMETER INSTALLATION  
 NORTH SPRINGFIELD DAM, NORTH SPRINGFIELD, VERMONT  
 Delivery Order No. 1  
 Contract DACW33-87-0002

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ITEM NO	SUPPLIES/SERVICES	UNIT	UNIT PRICE	ESTIMATED QUANTITY			ESTIMATED COST
				PZ-13	PZ-14	TOTAL	
3.	SURVEYING						
3.1	Mobilization and Demobilization	JOB	180.00			1	180.00
3.3	Mileage from/to Contractor's equipment storage site located in Manchester, NH	MI	0.35			200	70.00
3.4	Survey crew and equipment	DAY	440.00			1	440.00
6.	MOBILIZATION AND DEMOBILIZATION ONE DRILL RIG, CREW AND AUXILIARY EQUIP						
6.1	Mobilization and Demobilization	JOB	700.00			-1	700.00
6.3	Mileage from/to Contractor's equipment storage site located in Manchester, NH	MI	1.15			200	230.00
6.5	Standby time/on site moves	HR	75.00	4	4	24	1800.00
13.	DRIVE SAMPLE BORING (SPT) WITHOUT CASING						
13.1	0-30 ft. depth	EA	13.00	5	5	10	130.00
13.2	31-50 ft. depth	EA	16.00	1	1	2	32.00
18.	DRIVING AND PULLING CASING						
18.2	HX and 6-inch size	LF	28.00	26	26	52	1456.00
19.	DRIVING CASING AND LEAVING IN PLACE						
19.5	HX casing	LF	18.00	5	5	10	180.00
20.	CASING AND PIPE						
20.3	HX casing	LF	25.00	7	7	14	350.00

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TABLE C2 - ESTIMATE OF CONTRACTOR COSTS FOR PIEZOMETER INSTALLATION  
 NORTH SPRINGFIELD DAM, NORTH SPRINGFIELD, VERMONT  
 Delivery Order No. 1  
 Contract DACW33-87-0002

Page 2 of 2

ITEM NO	SUPPLIES/SERVICES	UNIT	UNIT PRICE	ESTIMATED QUANTITY			ESTIMATED COST
				PZ-13	PZ-14	TOTAL	
24.	PIEZOMETER						
24.1	Casagrande type, 0-50 ft. depth	LF	15.00	30	30	60	900.00
32.0	Crane and Operator	DAY	896.00			1	896.00

Contingency (15%) 1104.60

TOTAL ESTIMATED COST 8468.60

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APPENDIX D

ESTIMATED COSTS FOR A/E SERVICES

Table D1 - Man-Hour Breakdown by Personnel Category  
Piezometer Installation and Repair

Table D2 - A/E Cost Breakdown  
Piezometer Installation and Repair

Table D3 - Breakdown of A/E Expenses  
Piezometer Installation and Repair

TABLE D1 - MAN-HOUR BREAKDOWN BY PERSONNEL CATEGORY  
PIEZOMETER INSTALLATION AND REPAIR  
Townshend Dam and North Springfield Dam, Vermont

	Principal	Project Manager	Geotechnical Engineer	Drafts- person	Technical Typist
1. Prepare for field work	4	8	8	-	-
2. Observe piezometer in- stallation (based on 7 weeks of work)	7	35	322	-	-
3. Prepare draft engineering report	4	12	40	8	16
4. Prepare final engineering report	2	6	16	4	4
	<hr/>	<hr/>	<hr/>	<hr/>	<hr/>
TOTAL	17	61	386	12	20

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TABLE D2 - A/E COST BREAKDOWN  
PIEZOMETER INSTALLATION  
AND REPAIR  
Townshend Dam and  
North Springfield Dam, Vermont

(1) Direct Labor Costs (by personnel categories)

<u>Category</u>	<u>Hours</u>	<u>Average Wage Rate</u>	<u>Category Total</u>
Principal	17	\$26.00	\$ 442.00
Project Manager (Geotechnical)	61	21.00	1,281.00
Engineer (Geotechnical)	386	17.00	6,562.00
Draftsperson	12	13.25	159.00
Technical Typist	20	9.00	<u>180.00</u>
Subtotal, Direct Labor			\$ 8,624.00

(2) Overhead on Direct Labor (160% of Direct Labor) \$13,798.40

(3) Materials, Supplies (see Table D3 for breakdown) -0-

(4) Travel (See Table D3 for breakdown) 2,242.00

(5) Other Costs (See Table D3 for breakdown) 200.00

Total Costs \$24,864.40

(6) Profit (12%) \$ 2,983.73

Total Fee \$27,848.13

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TABLE D3 - BREAKDOWN OF A/E EXPENSES  
PIEZOMETER INSTALLATION  
AND REPAIR  
Townshend Dam and North  
Springfield Dam, Vermont

1. Travel

a. Observe inclinometer installation

(1) Full-time observation by engineer	
Per diem 7 weeks x 5 days/wk x \$50/day	\$1,750.00
Mileage 7 trips x 300 mi/trip x \$0.205/mi	430.50

(2) Site visit by project manager	
Mileage 300 mi x \$0.205/mi	<u>61.50</u>

Total Travel	\$2,242.00
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2. Other Costs

a. Telephone

During observation of installations	\$ 100.00
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b. Report Reproduction	<u>100.00</u>
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Total Other Costs	\$ 200.00
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Total Expenses	\$2,442.00
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